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SP700-C-Biodiesel: A Primer

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Biodiesel: A Primer

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Introduction

Diesel fuel is widely used throughout the transportation, construction and agricultural industries of the United States. However, concern has grown in recent years related to the nation's dependence on foreign oil for fuels like diesel and environmental impacts of petroleum-based diesel use. An alternative that has developed is biodiesel. Biodiesel is a renewable, biobased fuel that is created from oilseed crops, vegetable oils and animal fats. It can be used in place of traditional petroleum-based diesel fuel.

Biodiesel has several advantages, including reduced emissions and the fuel's biodegradable and nontoxic nature. Biodiesel is considered carbon neutral, in that it does not produce carbon dioxide. In 2007, petroleum-based diesel consumption in the United States was 64.6 billion gallons. In early 2008, the U.S. had the capacity to produce more than 2.2 billion gallons of biodiesel per year or the equivalent of just over 3 percent of total petroleum diesel consumption.

Producing Biodiesel

Biodiesel is produced by combining fatty oils with alcohol. Sources of these oils include agricultural crops, such as soybeans, canola and peanuts, recycled restaurant "fry" greases and oils, algal oils and animal fats often obtained from a meat processing facility. When using agricultural crop oils, the crop seeds are crushed, and oils are released from the seed. Animal fats, fry greases and oils can be collected from rendering facilities and restaurants. Certain algae contain up to 50 percent oil in their structure and can be used to produce oils for the biodiesel process as well[1]. Regardless of the oil source, all oils must be purified to remove water and other impurities prior to the biodiesel conversion process.

[1]Producing biodiesel from algae is a relatively new technology and has not yet been commercialized. Currently, it is the focus of a large volume of research and several pilot-scale production ventures have begun to develop.

Soybeans in field ready for harvest. *Credit: USDA*

Soybeans to be crushed for biodiesel. *Credit: Fred Witte, USDA*

To produce biodiesel, these oils go through a transesterification process. The clean oils are mixed with an alcohol, most often methanol, and a catalyst like sodium hydroxide. The catalyst enables the tranesterification reaction to proceed in a highly efficient manner, yielding fatty acid methyl esters and glycerin as products. When the reaction is complete, a layer of glycerin mixed with unreacted alcohol and catalyst is removed from the methyl ester-rich layer. The alcohol is recovered and reused. The glycerin by-product is recovered, refined and used in cosmetics and other industries. The methyl esters are, in reality, biodiesel. The biodiesel is "washed" several times through a filtering process to remove residual amounts of catalyst materials and glycerin.

Oftentimes, biofuels are evaluated for how much energy it takes to produce the fuel versus the amount of energy provided by the new fuel. The energy needed to produce the fuel is measured through the "life-cycle" of the fuel and this number includes all energy needs from planting seeds or pumping oil out of the ground until the finished fuel is ready for pumping into a vehicle. This is sometimes referred to as the fossil energy ratio. For biodiesel, the fossil energy ratio is 3.2. In other words, for every unit of fossil energy it takes to make biodiesel, 3.2 units of equivalent energy is produced. More energy is derived from biodiesel than it takes to produce it. Petroleum diesel has a negative fossil energy ratio (0.833), meaning it takes more energy to produce than is provided by the end fuel.

Using Biodiesel

Biodiesel is not raw vegetable oil! Using raw vegetable oils in a diesel engine will work, but the oils are thicker than biodiesel and can leave significant deposits in the engine. Raw vegetable oil use can also lead to a host of other engine problems that can reduce an engine's life. Biodiesel is a refined fuel, meaning that these impurities have been removed, and it will not cause problems such as clogged fuel filters and excessive deposits in engines.

Biodiesel production facility. *Credit: Kelly Tiller, University of Tennessee*

Biodiesel is sold in a variety of ways. Most often, it is sold as a blend with regular diesel. These blends can be B-10 (10 percent biodiesel, 90 percent diesel), B-20 (20 percent biodiesel, 80 percent diesel), and so on up to B-100 or 100 percent biodiesel. As opposed to a fuel like ethanol, using biodiesel does not require significant engine modifications. Current diesel engines can burn biodiesel at low blend rates without mechanical problems. Many engines built since 1994 are also capable of burning B-100. Prior to burning biodiesel, though, it is a good idea to check your vehicle manufacturer's warranty and owner's manual to be sure it is covered and to see which blends of biodiesel your vehicle can burn. If no information is available on biodiesel in the owner's manual, consult your automobile dealer or manufacturer.

Using B-100 comes with several benefits and issues of which users need to be aware. Biodiesel is completely biodegradable and non-toxic. This means, in the event of a fuel spill or related incident, biodiesel would cause far less concern for or damage to the environment. Biodiesel is also less flammable than petroleum diesel,

as it has a flash point about 100 degrees C higher than petroleum diesel. All of these attributes make biodiesel safe to produce, handle and transport.

Biodiesel has also been shown to reduce emissions, relative to petroleum-based diesel, when combusted. Compared to petroleum diesel, biodiesel significantly reduces the emission of carbon monoxide, carcinogenic compounds, air toxics, sulfurous compounds, particulate matter and carbon dioxide. Research is underway to better evaluate biodiesel effects on other emissions, such as nitrous oxide.

The energy content of biodiesel is another issue. A pure gallon of biodiesel contains about 8 percent less energy than a gallon of petroleum diesel. Many users do not notice a decline in performance or fuel economy, but it may be more noticeable at high blends of biodiesel. When using a low-level blend of biodiesel, such as B-20, energy per gallon is only reduced by 1-2 percent, and most users of B-20 report no noticeable change in the performance of their engines. The common measure of diesel power is called the cetane number. This number measures the amount of time between the injection of the fuel and the point of combustion in the engine. A higher number indicates shorter fuel ignition times and a better-quality fuel. Short ignition times provide for a longer combustion time in the engine, providing more power. This is especially important in higher speed diesel vehicles, such as on the road trucks. Petroleum diesel cetane numbers generally range from 40-42. Soy-based biodiesel cetane numbers average 48-50, indicating a higher-quality fuel than petroleum diesel.

Another common issue relating to diesel fuel is the gel point, or the temperature at which diesel will begin to solidify. Biodiesel (B-100) tends to gel at a higher temperature than petroleum diesel. The actual point of gelling depends on the oil used to make the biodiesel. Animal fats will gel at high temperatures (50-60 degrees F) while the more common vegetable oil-based biodiesel will gel at 25-40 degrees F. To prevent gelling, an additive can be mixed with the fuel, or it can be stored in heated fuel tanks. However, cold-climate customers who want to use B-100 need to be cautious. Low levels of biodiesel blends, like B-20, typically do not have the gelling issue of pure biodiesel. Their gel point is more in line with that of petroleum diesel.

B-20 Biodiesel Pump. *Credit: Samuel Jackson, University of Tennessee*

A common problem most users of biodiesel will face relates to fuel filters. The burning of petroleum diesel in an engine leaves residue deposits in the fuel tank, in fuel lines and in other parts of the engine. Biodiesel acts as a solvent, thereby releasing these deposits and cleaning the engine. As these deposits are released prior to combustion of the fuel, they are collected by the fuel filter. A new user of biodiesel will need to initially change the fuel filter, as these deposits are flushed out by the biodiesel, but after the first few changes, most of the debris has been removed and a regular fuel filter schedule can be resumed.

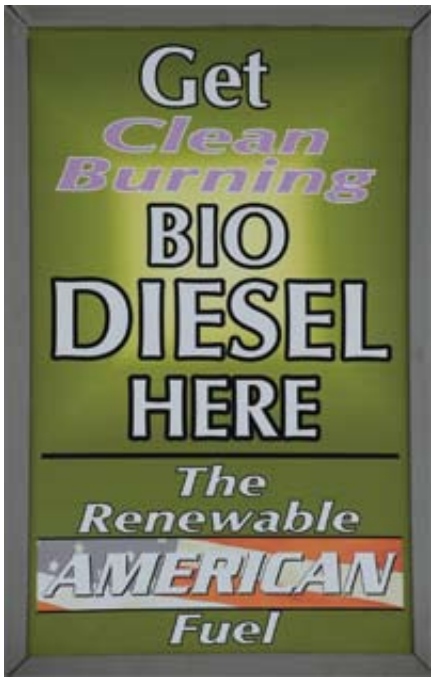
Where can I purchase biodiesel? Biodiesel, like any petroleum fuel, is subject to ASTM International standards. Any biodiesel sold commercially must meet these quality standards. Before purchasing biodiesel, make sure the supplier's product meets these specifications. Biodiesel is the most widely available biofuel. Tennessee has approximately 56 refueling stations that sell biodiesel. Most often, these stations offer a blend of biodiesel, such as B-10 or B-20. Several fuel station chains and many farm supply stores offer biodiesel. Please visit http://www.eere.energy.gov/afdc/fuels/biodiesel_locations.html to find a location near you.

For More Information

To learn more about the production and utilization of biodiesel, please visit one of these resources.
BioWeb: An online resource for bioenergy and bioproducts – http://bioweb.sungrant.org

National Biodiesel Board – http://www.biodiesel.org/

US Dept. of Energy Alternative Fuels and Advanced Vehicles Data Center – http://www.eere.energy.gov/afdc/fuels/biodiesel.html



A poster advertising biodiesel at a Tennessee fuel station. *Credit: Samuel Jackson, University of Tennessee*

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